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INSTRUCTION MANUAL

BAIRD-ATOMIC INC.

MODEL 412

PRECISION LINEAR AND LOGARITHMIC RATEMETER.

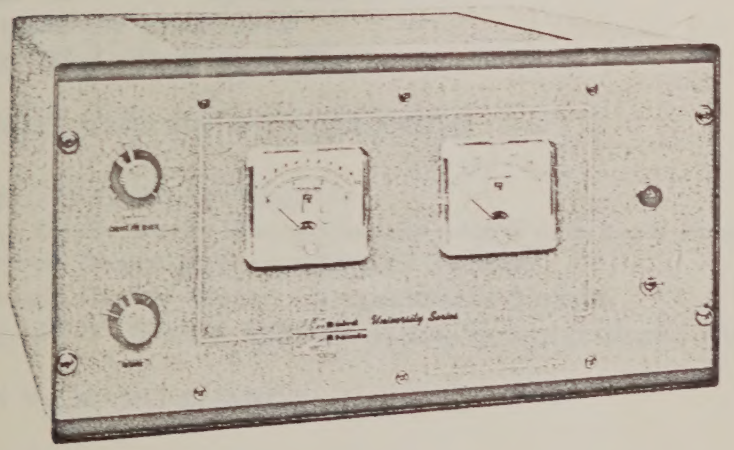
MISSILE & SPACE SYSTEMS DIVISION
DOUGLAS AIRCRAFT COMPANY, INC.
SANTA MONICA/CALIFORNIA

DOUGLAS

Instruction Manual

Model 412

Precision Linear and Logarithmic Ratemeter



Baird® Atomic

Baird-Atomic, Inc.

33 University Road, Cambridge 38, Massachusetts

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SECTION I. GENERAL DESCRIPTION

A. Purpose and Applications

The Model 412 Precision Dual Rate Meter displays the rate at which emissions or particles from radioisotopes are detected by radioactivity counting systems. This counting rate appears on two scales, a linear scale adjustable for full-scale readings from 30 counts per minute to 1,000,000 counts per minute and a logarithmic scale calibrated from 10 to 1,000,000 counts per minute. The Model 412 will simultaneously drive any standard potentiometer - or galvanometer-type recorder from both linear and log scales.

The dual display combines the accuracy and sensitivity of a linear meter with the wider dynamic range of information obtainable from a log scale. Thus, the log scale can establish the count-rate level which may then be analyzed in detail with the linear circuit. Similarly, the log scale will detect or preserve information which is of too high or too low a level to be registered on a particular linear range.

B. Specifications

Ranges: Linear Scale Selectable by 10-position front panel switch

0 to 30 cpm	0 to 100,000 cpm
0 to 100 cpm	0 to 300,000 cpm
0 to 300 cpm	0 to 1,000,000 cpm
0 to 1,000 cpm	
0 to 3,000 cpm	
0 to 10,000 cpm	
0 to 30,000 cpm	

Logarithmic Special 5-cycle log scale

10 cpm to 1,000,000 cpm

Provision for Zeroing: Available on both linear and logarithmic scales

Accuracy: Linear: Better than 1% on all scales
Log: Percent error of true counting rate: 15%
Note: at 10^6 cpm, this corresponds to 1% of the log.

Input: 5v negative minimum (Schmitt discrimination)
Impedance 510,000 ohms

Resolving Time: Faster than 3μ seconds

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Time Constants:	Independently selectable (only on linear scale) by 6-position front panel switch 0.3 sec 1.0 sec 3.0 sec 10.0 sec 30.0 sec 100.0 sec For fast-warning applications the log scale has a time constant inversely dependent on the counting rate.
Controls:	Power switch, scale switch, time constant switch
Output Indicators:	Front Panel Meters Separate log and linear 3 1/2" panel meters (1% accuracy) Recorder Drive Cathode follower output from both linear and log scales: 0 to 10 mv 0 to 100 mv 0 to 1 ma
Receptacles:	Input BNC (JK-36) Recorder Outputs Universal binding posts
Power Requirements:	115v AC, 60-cycle, at 1.5 amps
Dimensions:	19" w x 8 3/4" h x 14" d
Net Weight:	58 lbs
Shipping Weight:	70 lbs

C. Brief Circuit Description

Signals from an amplifier go to a Schmitt discriminator circuit and then to a flip-flop. A clamp circuit controls the amplitude of the square waves which then go to a cathode follower driver. The two outputs from the cathode follower go to the linear and log sections of the meter. The linear section uses a diode pump circuit with a VTVM. The log characteristic results from summing the output from a set of four diode pump circuits, with differing time constants feeding a VTVM.

SECTION II. INSTALLATION

Location:

The equipment consists of one self-contained unit. It may either be used in its own cabinet placed on a bench or table, or it may be mounted in a standard 19" rack. Since no side access is required, it can be placed next to a wall or between other units. There should be a back clearance behind the equipment sufficient to make connections. Baird-Atomic instruments have a unique "chimney" construction which reduces the operating temperatures by free-flow ventilation and permits ready access to all parts of the instrument. Therefore if mounting in a rack, be certain that there are no top-to-bottom obstructions to the free flow of air.

SECTION III. OPERATION

Table III-1: Connections to Other B-A Equipment

B-A Model No.	From Jack No. on Associated B-A Equipment	To Jack No. on 412	B-A Cable No.
204B	J4(UHF)	J101(BNC)	4
212	J105(BNC)	"	5
215	J105(BNC)	"	5
218	J4(UHF)	"	4
255 and 132	J103(AN) on 255 to J101(AN) on 132	"	1
	J102(BNC) on 132 to J101 on 412		5
510	J2(UHF)	"	4

Table III-2: Switches and Knobs

Control	Schematic Design	Type	Circuit Function
FULL SCALE RANGE	S101	10-position, 4 deck rotary	Deck 1: selects the bleeder resistor necessary for a full-scale range reading that is a multiple of 10 or 3. Deck 2: selects lower tank resistor for 300 K and 1 M ranges. In these positions all time constants must be divided by 10. Deck 3: selects proper charging condenser for each range.
TIME CONSTANT	S102	6-position 2 deck rotary	Deck 1: chooses time constant by varying tank condenser.
POWER	S201	DPDT	Makes-breaks primary power

See Table III-1 for proper connection of the Model 412 in compatible Baird-Atomic systems.

Selection of Linear Range: Set the linear range switch at its highest position. After the power switch S201 has been turned on and the rest of the counting system is working, a reading should appear on the logarithmic (right-hand) meter. This will indicate the proper position for the range switch on the linear scale. E.g. a reading of 10^4 (10,000 counts) on the log scale suggests that you place the linear range switch, for example, at the 30K (30,000) position. Be careful not to choose a range position so high that the meter deflection is scarcely perceptible or relatively hard to read accurately. A little practice with the range switch will indicate how the same count appears at various points on the meter, some more useful than others. One of the special advantages to this ratemeter is illustrated by Fig. III-1. If the range switch is placed at the 100K position, note that the 638 kev photopeak is almost imperceptible on the linear plot. In this manner the log scale will preserve information otherwise lost.

Selection of Time Constant: Note that the time constant selector only operates in the linear section.

No absolute directions can be given on selection of the time constant since this depends very much on the nature of the work to be done. To illustrate, if a time constant is too short for a particular counting rate, the meter needle will "jitter" since the tank condenser has a chance to discharge between counts. Yet a relatively short time constant is desirable for following a rapid change in counting rate -- a long time constant making the response too sluggish. If the pulses applied to the count ratemeter are random in time, the reading will fluctuate. Expressed as a function of counting rate and time constant, the percent of statistical fluctuation can be shown (Elmore and Sands, Electronics, p. 252) to be:

$$E = \frac{134}{\sqrt{\frac{NT}{30}}}$$

Where N = counts per minute and T = the time constant in seconds. Thus, a longer time constant will give less statistical error.

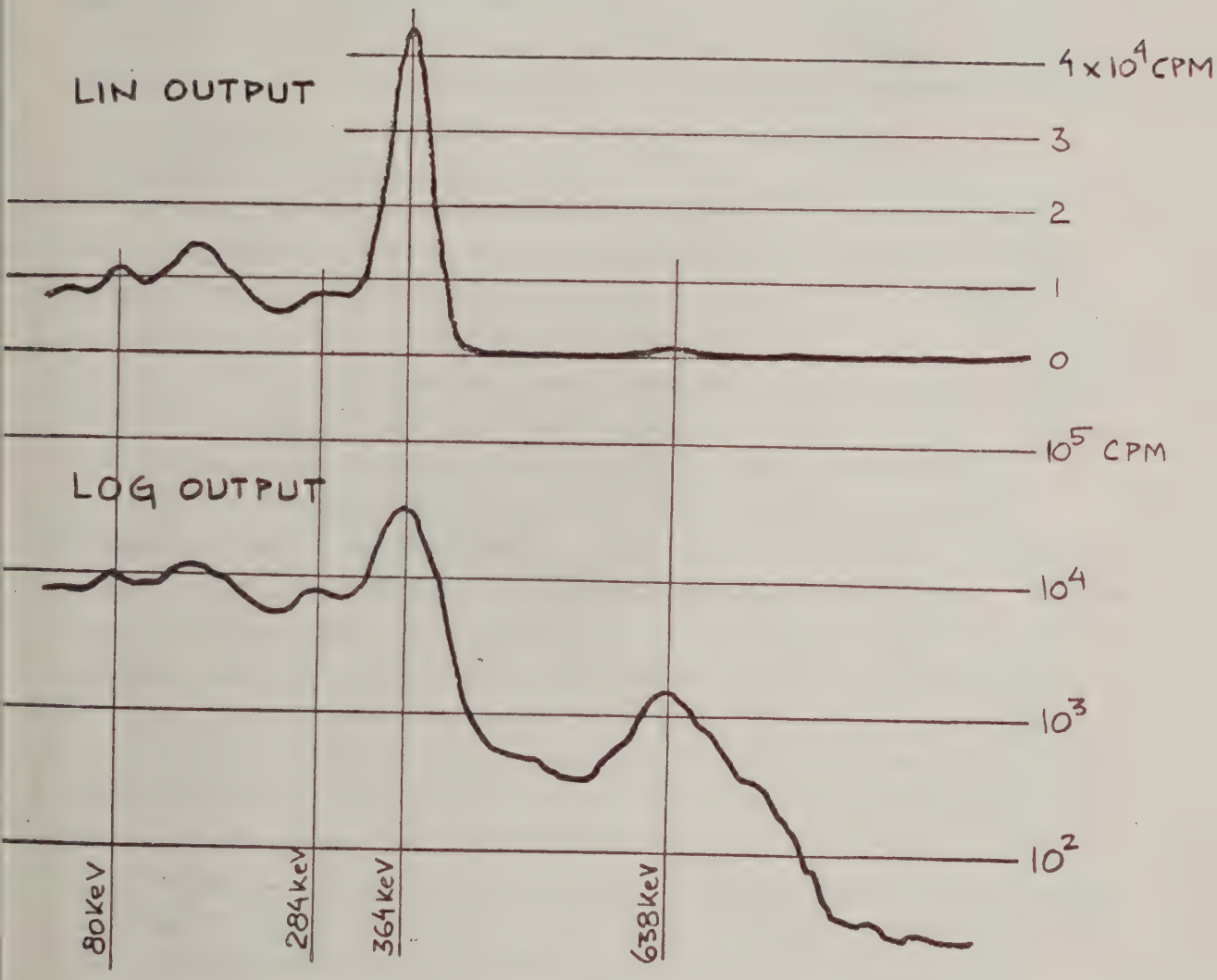

Fig. III-1. Energy Spectrum of I^{131} recorded with Model 412 Rate Meter

Fig. III-2, a graph of this relationship for various time constants, will aid in selecting the counting statistics you wish for your particular problem. To summarize, the higher the time constant setting, the less needle "jitter", the better the counting statistics, and the poorer the response to rapid changes in counting rate.

Outputs for Recorders:

The 412 provides outputs in both the linear and logarithmic section for 1 ma, 100 mV, and 10 mV full-scale recorders. Terminals 5 and 6 are ground. The respective outputs are taken between adjacent terminals. For example, the 100 mV log output is taken from terminals 7 and 8. For calibration a 1300 ohm resistor was substituted for a 1 ma recorder and therefore recalibration of the span adjustment might be necessary if a 1 ma recorder is used, since the recorder internal resistance might vary from this.

If such re-calibration is necessary, the following procedure is suggested: With a constant counting rate at the input, select a range to give a reading above midscale, and record indicated rate and range. Compare the "3" reading range (or a range "1" if "3" range was used first). The counting rate indicated should be the same on both scales. Remove dummy resistor (1.3 K) from barrier strip and connect recorder with minus side toward center of barrier strip. Vary R150 to obtain the same reading on the meter scale as with the dummy resistor. Do the same on the "3" range, now varying R148. Note: when switching the range selector from a "1" range to a "3" range, the meter might register off-scale for a short time. If this happens, switch to the lowest time constant to establish equilibrium, then resume previous time constant setting again.

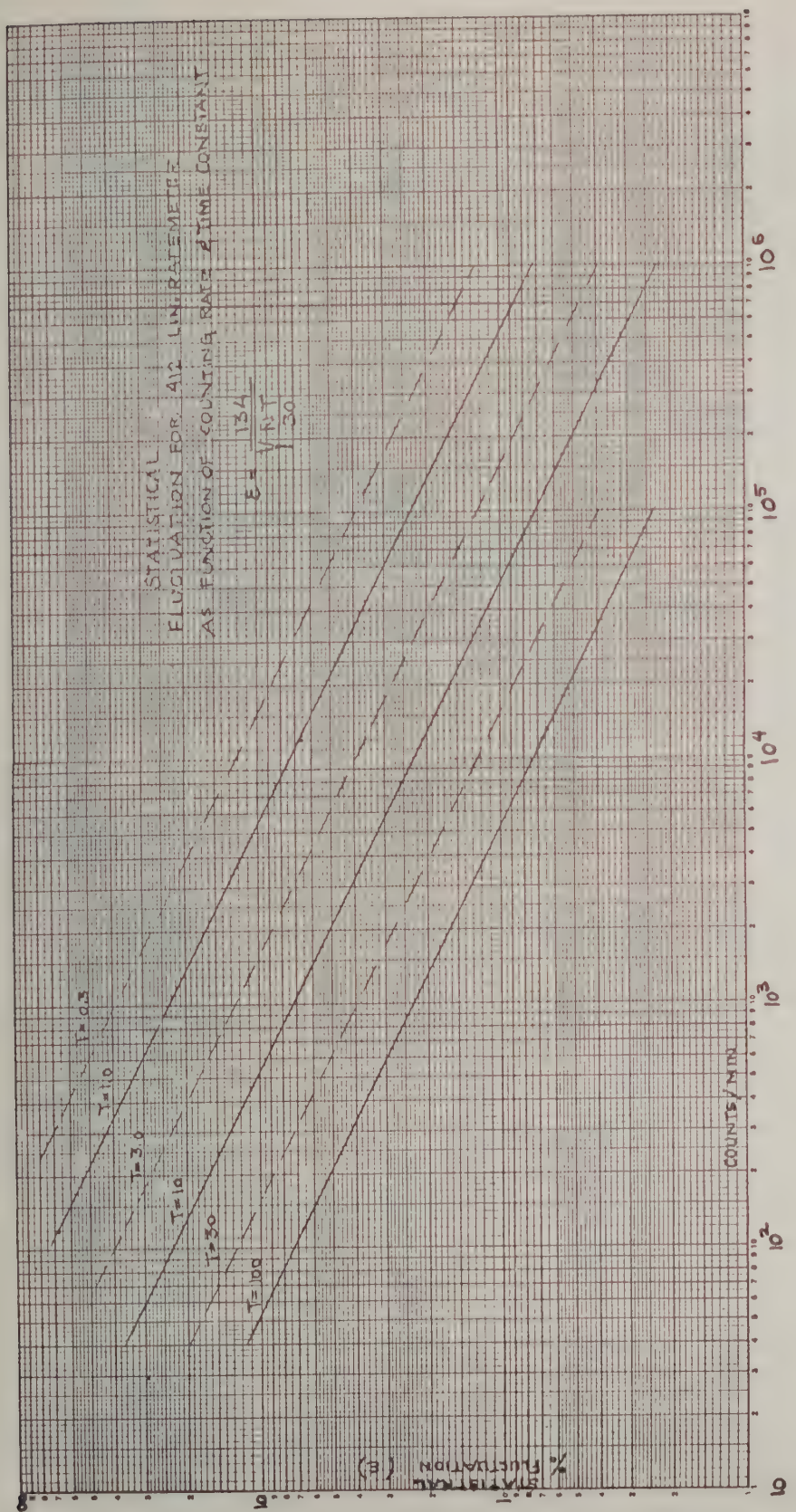

Fig. III-2 Statistical fluctuation for Model 412 Lin. Rate Meter as function of counting rate and time constant

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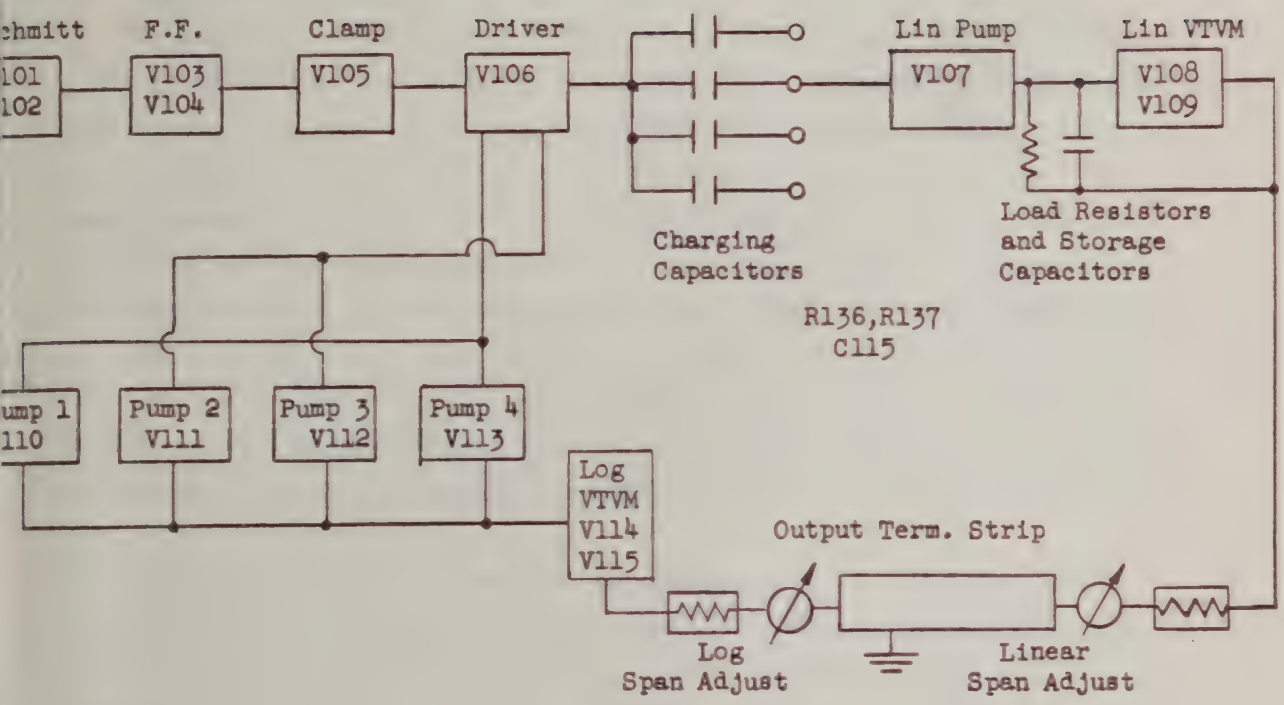

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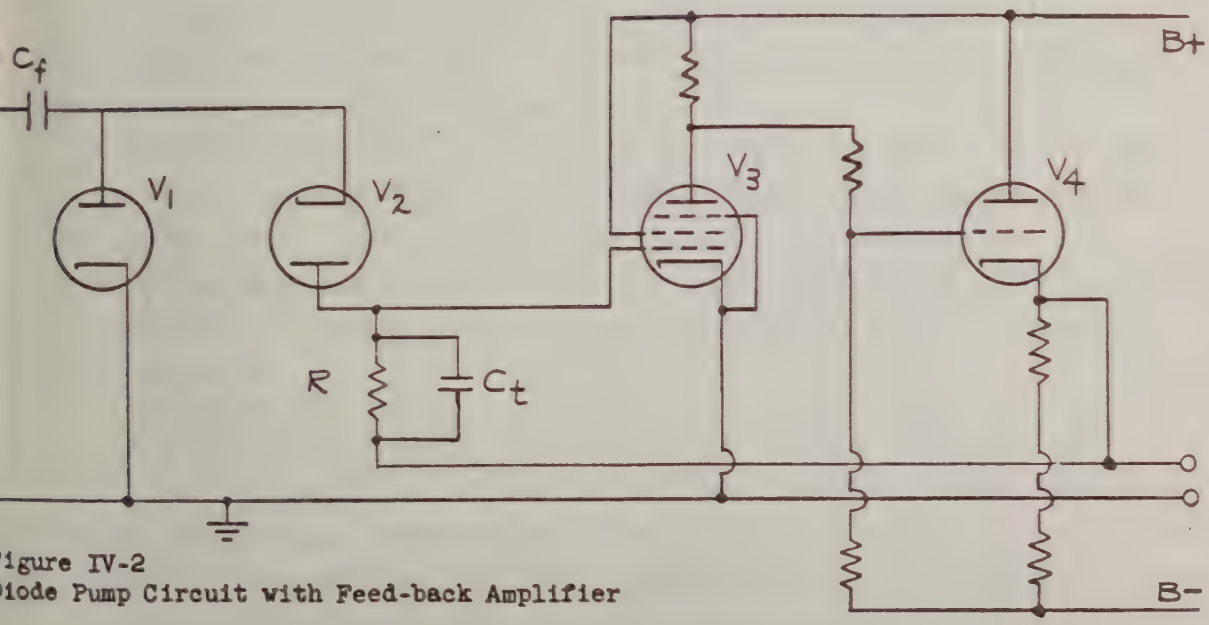
lock Diagram



igure IV-2
iode Pump Circuit with Feed-back Amplifier

SECTION IV. CIRCUIT DESCRIPTION

See Block Diagram, IV-1

Negative pulses exceeding 5 V amplitude will trigger the input Schmitt circuit composed of V101 and V102. V101 is normally conducting and V102 is normally cut off. As the signal approaches cut-off, the cathode voltage will initially decrease and the plate voltage of V101 begin to rise. The rapid increase in grid-to-cathode voltage of V102 will bring it into conduction and the subsequent increase in cathode voltage contributes to cutting off V101 while V102 conducts heavily. When the signal moves back in a positive direction, V101 begins to conduct, and the reverse action takes place: increase in V101 grid voltage causes a decrease in V102 grid voltage and the regenerative action returns V102 to cut-off. The output of the Schmitt circuit is a negative rectangular pulse to the trigger diode, V103.

The Schmitt circuit is used to trigger the flip-flop precisely; the flip-flop is used to generate a square wave of constant length after each input pulse. The trigger diode, V103, appears at the plate of the non-conducting triode and is transferred through one of the intrastage capacitors to the grid of the conducting section, causing its plate potential to rise. This in turn causes a positive pulse to be coupled to the grid of the non-conducting triode which starts to conduct. Successive negative triggers at the input will cause the flip-flop to shift very rapidly from one equilibrium state to the other. The mean period of the square wave output varies as the reciprocal of the pulse rate.

The dual-diode, V105, limits the excursions of the square wave to the range between 125V and 85V, insuring amplitude stability and a flat top to the square waves. V106, a double triode cathode follower, offers low driving impedance and therefore short charging time constants. One cathode of V106 feeds the linear portion of the ratemeter, the other drives the four log pumps.

Linear Section

Fig. IV-2 is a simplified illustration of the diode pump circuit with a feedback amplifier utilized in the linear section. Pulses from the cathode follower are applied to the feed condenser C_f. This condenser is alternately charged through V1 and discharged into the tank condenser C_t through V2. The voltage on C_t increases until the rate of loss-of-charge

through the leak resistor R is equal to the rate at which charge is fed into the condenser. Since the charge-per-pulse fed to the tank condenser is constant, the condenser voltage is proportional to the counting rate. This voltage is then measured by a VTVM calibrated in CPM. It is desirable that the condenser voltage be a large value compared to possible drifts in the VTVM. However, it is difficult to keep constant the charge-per-pulse fed to the tank circuit if appreciable voltage changes appear across the circuit. In order to permit a voltage of about 50 volts to be developed across the tank circuit while at the same time only a very small fraction of this voltage appears at the point to which the charge is fed from the feed circuit, negative feed-back is utilized. Note the tank circuit, C_t and R, is also a feedback element from V4 to V3. C_f discharges through V2 into C_t, but because of the feedback, practically all the resultant voltage-change appears at the side C_t remote from V2, since the amplifier circuit containing V3 and V4 keeps the potential of the grid of V3 at ground.

To turn to the specific circuit of the Model 412, the linear ratemeter provides ten frequency ranges by changing the charging capacitors (C110-113), related by factors of 10, the bleeder resistors R150,152 or R151, 153, and for the two highest ranges, the load resistor R136 (or R137).

A special feature of this linear ratemeter is that the time constant can be switched without affecting the reading of the meter. This is explained by the fact that only the capacitor value is changed and not the resistance value, as the current balance equation for steady-state conditions indicates. The total charge-per-pulse transferred to the storage capacitor is

$$\delta_{in} = C_f V_{in}$$

Since this happens $\bar{n}$ times per second, the current flow into the capacitor

$$i_{in} = \bar{n}\delta_{in} = \bar{n} C_f V_{in}$$

The total current leaking off from the storage capacitor through the load resistor (R136) is clearly

$$\frac{V_{out}}{R} = i_{out} \quad \text{and since } i_{out} = i_{in},$$

$$\frac{V_{out}}{R} = \bar{n} C_f V_{in} \qquad \text{or} \qquad V_{out} = (\bar{n} C_f R) V_{in}$$

Note that the storage capacitor does not appear in this expression if it is assumed that $\bar{n}$ is constant and V_{out} has reached a constant, steady state. It can be seen that switching time constants will not affect V_{out} since we do not vary R. Actually, V_{out} varies slightly for random pulses.

The VTVM consisting of V108 and V109 is high gain amplifier with 100% negative feedback and positive feedback from V109A to V108. As mentioned earlier, the negative feedback makes it possible to keep the grid of V108 at ground potential while having a relatively large voltage across the tank circuit. The positive feedback increases the size of the voltage swing of the plate of V108, thus improving the linearity of the VTVM.

Logarithmic Section

The basic circuit of the logarithmic section is the diode pump used above. Fig. IV-3 illustrates the manner in which this circuit is used to obtain a logarithmic charecteristic. Each of the pumps with time constants differing as shown below has range over which it has a logarithmic response; the sum of the individual contributions provides an output current logarithmically related to input frequency. The deviation from a truly logarithmic scale is never more than 1 degree of the meter reading.

The input to the charging condensers (C118, 120, etc.) comes from the cathode follower, V106, a somewhat higher voltage being fed to the two end pumps to minimize erroneous readings at the extremes of the scale. Current proportional to the voltage on the four storage capacitors (C119A, 119B, etc.) flows through the four bleeder resistors (R159, 160, etc.) to the virtual ground at the input to the VTVM of the log section. For any counting rate of $\bar{n}$ pulses per minute at the input, the sum of the currents is given by

$$\sum_{K=1}^{4} i_K = \frac{V_{in}}{10^7} \sum_{K=1}^{4} \frac{\bar{N}\, T_k}{\bar{N}\, T_K + 120}$$

where $T_1 = 10$
$T_2 = .3$
$T_3 = .009$
$T_4 = .0027$

Negative feedback from V115 to V114 holds the grid of V114 constant, while the change in voltage level required to maintain this virtual ground produces a current flow in M102 proportional to the log of the counting rate. Positive feedback is employed as in the linear VTVM.

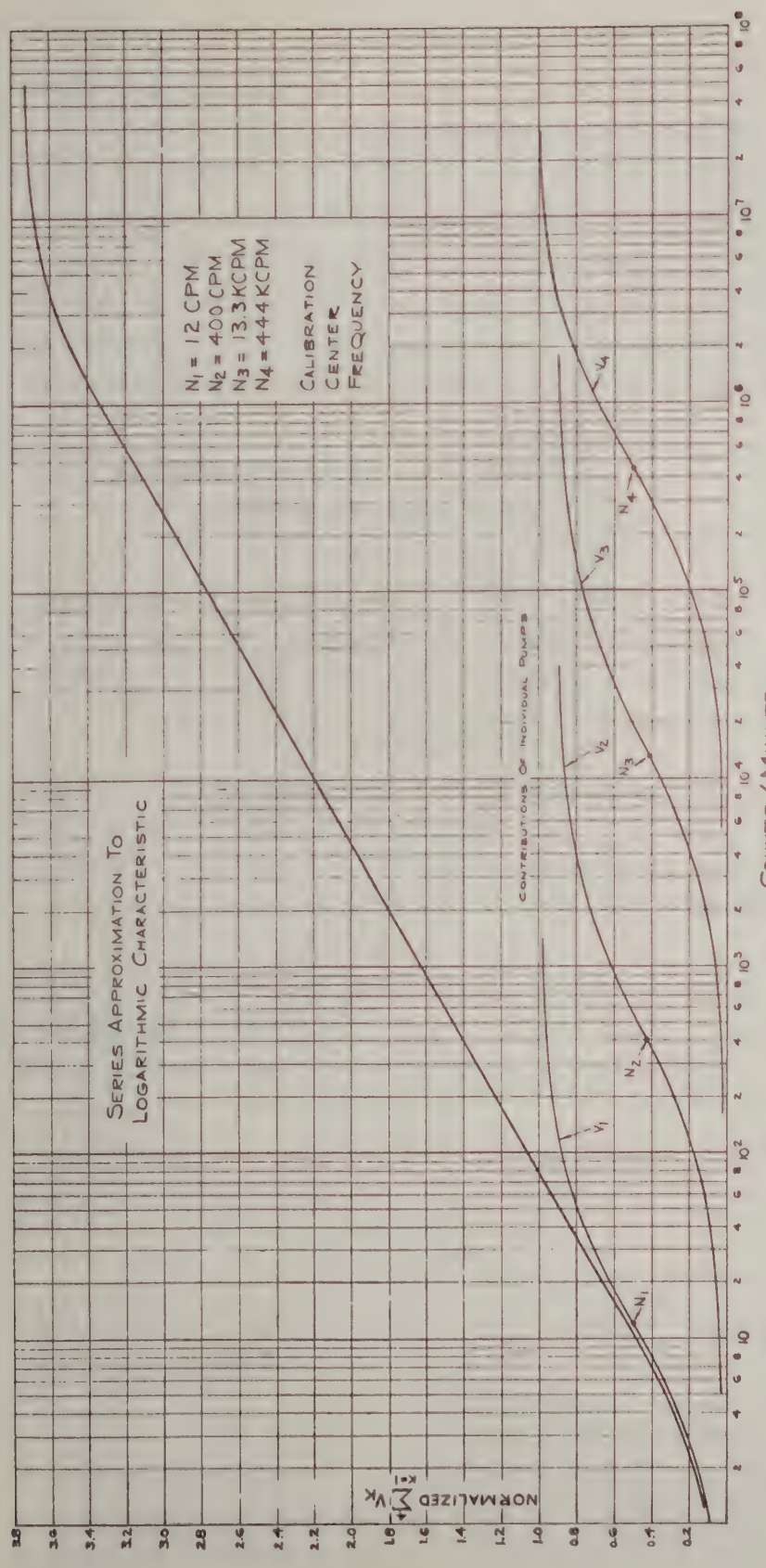


Fig. IV-3. Series approximation to logarithmic characteristic

SECTION V. MAINTENANCE

You can make a general check on the operation of the ratemeter by comparing its reading with the counts per minute totaled on a scaler. If the readings disagree significantly and all other possibilities have been checked, the ratemeter may require recalibration. As will be apparent, the process of calibrating is not easy and should only be attempted by someone experienced in such adjustments. Possibly some of the steps in the following complete test procedure will not be necessary in a recalbration.

1) Check of supply voltages:

B+	adjust to 265	plus or minus 1 V
B-	148 "	" " 2 V
filaments	6.3V "	" " 15% at 115V line

2) With no input signal applied (but power 'on') check:

LIN VTVM
a) zero - adjust R 141 for zero reading on LIN VTVM
b) measure cathode potential (pin 2,7) of V108 to read between 2.0 and 2.5 V
c) measure grid voltage (pin 2) of V109 to read between -5 and -8 V

LOG VTVM
a) adjust R 168 to read zero on log meter
b) measure cathode potential (pin 2,7) of V 114 to read between 1.0 and 2.0 V.
c) measure grid voltage (pin 7) of V 115: -5 to -8 V

3) The shunted meters have to give full scale deflection for 1 ma plus or minus 1% (for later production runs, not necessary - 1 ma meter will be standard).

4) Input Schmitt circuit: apply signal at J101 of following shape:

Polarity - negative
Amplitude - 5V
Rise time- 0.5 μsec
Decay time - 2-10 μsec
Pulse width - 0.4 - 4 μsec

Output at pin 5 of V 102 should have a minimum amplitude of 40 V.

5) Check of clamp: clamp bias to be

75 plus or minus 1 V (low)
115 " " " 2 V (high)

Attach probe of VTVM to pin 3, V 106 and apply input signal of shape specified in step 4 and a very slow rep rate (2 to 5 sec period). The voltage reading will swing from 84 plus or minus 2 V to 121 plus or minus 2V

in accordance with the action of the flip-flop.

Remove V105. The readings at the same point are now to be: below 68 V(low) and above 128 V(high). If these voltages differ from specified values, shunting R118 or R122 respectively and/or changing V 106 will help.

6) Adjustment of log pumps

a) Attach probe of an electrometer type VTVM to Pin 2,V110 (the charging terminal of C119A). Set lin range switch to 1M. Apply an input signal of specified shape and a frequency of about 10 kcpm. The meter should read -36V plus or minus 0.5 V. Increase frequency up to 1 mcpm. No decrease of the voltage reading should be noticeable.

b) Attach probe to V111, Pin 2(C 119B). The voltage at this point should read - 30 V plus or minus 1 V.

c) With the probe at the same point as under (b), set input frequency back to 400 cpm. (This is equal to a square wave period of 0.3 sec as seen at pin 3 of V106.) Adjust R164 until meter reads -15 plus or minus 0.5V.

d) Move probe to pin 7 of V112 (C125). At an input frequency of 13.3 kcpm adjust C122 for -15 plus or minus 0.5V.

e) Move probe to pin 2 of V113 (C126). At a frequency of 444 kcpm adjust C124 for 15 plus or minus 0.5V.

NOTE: Log pumps 1,2, and 3 have long time constants. In order to get a reading within 5% accuracy, you must wait 90 sec. for pump 2; 30 sec. for pump 3; and 0.3 sec. for pump 4.

7) Increase input frequency to 1 mcpm. Adjust range of Log section (R178) to read 1 mcpm on panel meter. Adjust R130 of linear section so that output of VTVM (pin 8, V109) reads 45 plus or minus 1 V. Adjust range '1' of lin section (R150) so that lin panel meter reads within 1%.

8) Change input frequency to 100 kcpm. Record reading of Log meter. Switch range switch to 100 kcpm and observe accuracy. If reading is not within 1%, check square wave at pin 8, V 106, or replace R137. Careless handling of deposited film resistors changes their value.

9) Change input to 10 kcpm. Record log meter reading. Switch range to 10 kcpm and adjust R131 until output voltage of Lin VTVM reads 45 V (this is now equivalent to full-scale reading.).

10) With same input frequency, switch range to 30 kcpm and adjust R148 to give correct reading on range '3' to within 1%.

11) Change input frequency to 1 kcpm. Record Log meter reading. Switch range to 1K and adjust R132 for full scale.

12) Change frequency to 100 cpm. Record Log reading and adjust Lin reading by means of R133 on 100 cpm range. It might be useful to go up-scale along 300 cpm, 3K cpm, etc. to re-check the calibration.

13) The reading of the Log section may deviate from the nominal reading by as much as 15-20%. If all readings are high, re-adjust the zero; if the 1 mcpm reading is high, the 10 kcpm reading is correct, and the 100 cpm reading is low, re-adjust the Log range. A little bit of practice will quickly lead to the best fit. Recall that the circuit is capable of an accuracy of 15%.

14) Check stability of reading vs. time constant setting. A change of time constant should not change the Lin reading more than 2%.

15) Check resistive divider R154, 155,182,183 for 100 mV and 10 mV output (1% tol).

16) After all adjustments are correct, tighten locknuts without changing the setting.

Maintenance points to be carefully inspected:

a) Catching diodes CR 103 and CR 104 (heat exposure).

b) Switch contacts clean and prec. resistors R136 and R137 undamaged.

c) Socket of V107 free of dirt and solder. Leakage at this point gives inaccuracy.

d) C115 and C119AandB terminals clean.

e) Prec. resistors at output barrier strip in good condition.

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SECTION VI

PARTS LIST

A. Ratemeter Section

Part No.	Description	B/A Desig.
C101	.01 µf, ceramic, 10%	CC 103-1
102	10 µµf, ceramic, 10%	CC 100-2
103	.1 µf, mylar, 20%, 600 V.	CP 104-11
104	27 µµf, ceramic, 10%	CC 270-1
105	22 µµf, ceramic, 10%	CC 220-1
106	22 µµf, ceramic, 10%	CC 220-1
107	27 µµf, ceramic, 10%	CC 270-1
108	Omitted	
109	Omitted	
110	200 µµf, mica, 5%	CM 201-1
111	.002 µf, mica, 5%	CM 202-1
112	.02 µf, mylar, 5%, 200 V.	CP 203-3
113	.2 µf, mylar, 5%, 200 V.	CP 204-1
114	.1 µf, mylar, 20%, 200 V.	CP 104-10
115	Multiple capac., .03, .07, .2, .7, 2, 7 µf, mylar, 200 V.	CP 705-1
116	.04 µf, ceramic disc, 20%	CC 403-1
117	.001 µf, ceramic, 10%	CC 102-1
118	1.0 µf, mylar, 20%, 200 V.	CP 105-3
119 A&B	10/10 µf, mylar, 100 V.	CP 106-1
120	.1 µf, mylar, 20%, 200 V.	CP 104-10
121	500 µµf, mica, 5%	CM 501-1
122	100-500 µµf, variable, Arco 304M	CV 101-2
123	100 µµf, mica, 5%	CM 101-1
124	19-160 µµf (variable), Arco 583	CV 161-1
125	1.0 µf, mylar, 20%, 200 V.	CP 105-3
126	.1 µf, mylar, 20%, 200 V.	CP 104-10

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SECTION VI

PARTS LIST

A. Ratemeter Section

Part No.	Description	B/A Desig.
C127	.04 μf, ceramic disc, 20%	CC 403-1
128	.001 μf, ceramic, 10%	CC 102-1
129	.001 μf, mica, 10%	CM 102-2
CR101	Diode 1 N 38 A	CR-23
102	Diode 1 N 38 A	CR-23
103	Diode, T 20 G	CR-19
104	Diode, T 20 G	CR-19
I101	Lamp, neon, NE-2	LA-3
102	Lamp, neon, NE-2	LA-3
103	Lamp, neon, NE-2	LA-3
J101	Connector, BNC	JK-36
102	Barrier Strip, 10 terminal Jones #10-141-Y	TR-54
M101	Meter, 200 μa, Triplett 327 PL	MT-24 C
102	Meter, 200 μa, Triplett 327 PL	MT-24 D
R101	24 K, 2 W, 5%, comp.	RCH 103J
102	24 K, 2 W, 5%, comp.	RCH 103J
103	3.3 K, 1 W, 5%, comp.	RCG 332J
104	150 K, 1/2 W, 5%, comp.	RCE 154J
105	510 K, 1/2 W, 5%, comp.	RCE 514J
106	15 K, 1/2 W, 5%, comp.	RCE 153J

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SECTION VI

PARTS LIST

A. Ratemeter Section

Part No.	Description	B/A Desig.
R107	75 K, 1/2 W, 5%, comp.	RCE 753J
108	4.7 K, 1 W, 5%, comp.	RCG 472J
109	10 K, 1 W, 5%, comp.	RCG 103J
110	100 Ω, 1/2 W, 5%, comp.	RCE 101J
111	100 K, 1/2 W, 5%, comp.	RCE 104J
112	Factory selected	
113	100 K, 1/2 W, 5%, comp.	RCE 104J
114	220 K, 1/2 W, 5%, comp.	RCE 224J
115	20 K, 1 W, 5%, comp.	RCG 203J
116	10 K, 2 W, 5%, comp.	RCH 103J
117	20 K, 1 W, 5%, comp.	RCG 203J
118	330 K, 1/2 W, 5%, comp.	RCE 334J
119	220 K, 1/2 W, 5%, comp.	RCE 224J
120	100 K, 1/2 W, 5%, comp.	RCE 104J
121	100 Ω, 1/2 W, 5%, comp.	RCE 101J
122 A	1 Meg, 1/2 W, 5%, comp.	RCE 105J
122 B	Factory Selected	
123	39 K, 5 W, 1%, wirewound (Dalohm)	RW 393-1
124	10 K, 3 W, 1%, wirewound (Dalohm)	RW 103-2
125	20 K, 3 W, 1%, wirewound (Dalohm)	RW 203-3
126	200 Ω, 1/2 W, 5%, comp.	RCE 201J
127	2 K, 1/2 W, 5%, comp.	RCE 202J
128	12 K, 1 W, 5%, comp.	RCG 123J
129	5.6 K, 3 W, 3%, wirewound (Dalohm)	RW 562-1
130	10 K, pot., 2 W, wirewound (Evenohm)	RA 103-2
131	10 K, pot., 2 W, wirewound (Evenohm)	RA 103-2

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SECTION VI

PARTS LIST

A. Ratemeter Section

Part No.	Description	B/A Desig.
R132	10 K, pot., 2 W, wirewound (Evenohm)	RA 103-2
133	10 K, pot., 2 W, wirewound (Evenohm)	RA 103-2
134	82 K, 2 W, 5%, comp.	RCH 823J
135	1.8 K, 1/2 W, 5%, comp.	RCE 182J
136	10 Meg, 1 W, 1%, film (Welwyn C13)	RF 106-4
137	1 Meg, 1/2 W, 1%, film (Welwyn C12)	RF 105-1
138	1 Meg, 1/2 W, 5%, comp.	RCE 105J
139	270 K, 1/2 W, 5%, comp.	RCE 274J
140	1.5 K, 1/2 W, 5%, comp.	RCE 152J
141	1K, pot., 2 W, 5%, carbon	RV 102-3
142	330 K, 1/2 W, 5%, comp.	RCE 334J
143	680 K, 1/2 W, 5%, comp.	RCE 684J
144	220 K, 1/2 W, 5%, comp.	RCE 224J
145	51 K, 1/2 W, 5%, comp.	RCE 513J
146	33 K, 1/2 W, 5%, comp.	RCE 333J
147	510 K, 1/2 W, 5%, comp.	RCE 514J
148	5 K pot., 2 W, 5%, carbon	RV 502-2
149	1.5 Meg, 1/2 W, 5%, comp.	RCE 155J
150	10 K pot., 2 W, wirewound	RA 103-2
151	33 K, 1 W, 5%, comp.	RCG 333J
152	39 K, 5W, 1%, wirewound	RW 393-1
153	10 K, 3 W, 1%, wirewound	RW 103-2
154	100 Ω, 1/2 W, 1%, film (Welwyn C12)	RF 101-6
155	10 Ω, 1/2 W, 1%, film (Welwyn C12)	RF 100-1
156	20 K, 1/2 W, 5%, comp.	RCE 203J
157	20 K, 1/2 W, 5%, comp.	RCE 203J
158	20K, 1/2 W, 5%, comp.	RCE 203J

MODEL 412 INSTRUCTION MANUAL

SECTION VI

PARTS LIST

A. Ratemeter Section

Part No.	Description	B/A Desig.
R159	10 Meg, 1 W, 1%, film (Welwyn C13)	RF 106-4
160	10 Meg, 1 W, 1%, film (Welwyn C13)	RF 106-4
161	10 Meg, 1 W, 1%, film (Welwyn C13)	RF 106-4
162	10 Meg, 1 W, 1%, film (Welwyn C13)	RF 106-4
163	2 Meg, 1/2 W, 5%, comp.	RCE 205J
164	5 Meg pot., 2 W, 5%, carbon	RV 505-1
165	1 Meg, 1/2 W, 5%, comp.	RCE 105J
166	270 K, 1/2 W, 5%, comp.	RCE 274J
167	750 Ω, 1/2 W, 5%, comp.	RCE 751J
168	1 K pot., 2 W, 5%, carbon	RV 102-3
169	330 K, 1/2 W, 5%, comp.	RCE 334J
170	680 K, 1/2 W, 5%, comp.	RCE 684J
171	220 K, 1/2 W, 5%, comp.	RCE 224J
172	51 K, 1/2 W, 5%, comp.	RCE 513J
173	33 K, 1/2 W, 5%, comp.	RCE 333J
174	510 K, 1/2 W, 5%, comp.	RCE 514J
175	900K, 1/2 W, 1%, film (Welwyn C12)	RF 904-1
176	1.5 Meg, 1/2 W, 5%, comp.	RCE 155J
177	33 K, 1 W, 5%, comp.	RCG 333J
178	250 K pot., 2 W, 5%, carbon	RV 254-1
179	10 K, 1 W, 5%, comp.	RCG 103J
180 A	~82 Ω, 1/2 W, 5%, comp.	RCE 820J
180 B	Factory selected	
181	~82 Ω, 1/2 W, 5%, comp.	RCE 820J
181 B	Factory Selected	
182	10 Ω, 1/2 W, 1%, film (Welwyn C12)	RF 100-1
183	100 Ω, 1/2 W, 1%, film (Welwyn C12)	RF 101-6
184	1.3 K, 1 W, 5%, comp.	RCG 132J

MODEL 412 INSTRUCTION MANUAL

SECTION VI

PARTS LIST

A. Ratemeter Section

Part No.	Description	B/A Desig.
R185	1.3 K, 1 W, 5%, comp.	RCG 132J
186	2 K, 1 W, 5%, comp.	RCG 202J
187	1 Meg, 1/2 W, 5%, comp.	RCE 105J
S101	Switch, rotary, 10 position	SR-53
102	Switch, rotary, 6 position	SR-49
V101	6AK5	6AK5
102	6AK5	6AK5
103	6AL5	6AL5
104	5965	5965
105	6AL5	6AL5
106	12BH7	12BH7
107	6AK5	6AK5
108	6AK5	6AK5
109	6BQ7A	6BQ7A
110	6AL5	6AL5
111	6AL5	6AL5
112	6AL5	6AL5
113	6AL5	6AL5
114	6AL5	6AL5
115	6BQ7A	6BQ7A

MODEL 412 INSTRUCTION MANUAL

SECTION VI

PARTS LIST

B. Power Supply

Part No.	Description	B/A Desig.
C201	4 μf, 600 V, oil	CP 405-1
202	.1 μf, 600 V, paper	CP 104-11
203	.1 μf, 600 V, paper	CP 104-11
204	24/24 μf, 400 V, electrolytic	CE 246-1
205	0.47 μf, 600 V, paper	CP 474-2
206	24/24 μf, 400 V, electrolytic	CE 246-1
CR201	Rectifier, silicone, 1200 PIV, 500 ma, Sarkes #120SM	CR-36
202	Rectifier, silicone, 1200 PIV, 500 ma, Sarkes #120SM	CR-36
203	Rectifier, selenium, 1500 PIV, 20 ma, Syntron #B-58591	CR-40
204	Rectifier, selenium, 1500 PIV, 20 ma, Syntron #B-58591	CR-40
F201	Fuse, 2A	FS-14
202	Fuse, 2A	FS-14
J201	Receptacle, A-C	JK-79
PL201	Pilot Light NE-51	LA-8
R201	120 Ω, 2 W, 5%, comp.	RCH 121J
202	120 Ω, 2 W, 5%, comp.	RCH 121J
203	500 Ω, 10 W, 5%, wirewound	RW 501-2
204	270 K, 1/2 W, 5%, comp.	RCE 274J
205	220 K, 1/2 W, 5%, comp.	RCE 224J
206	100 Ω, 1/2 W, 5%, comp.	RCE 101J

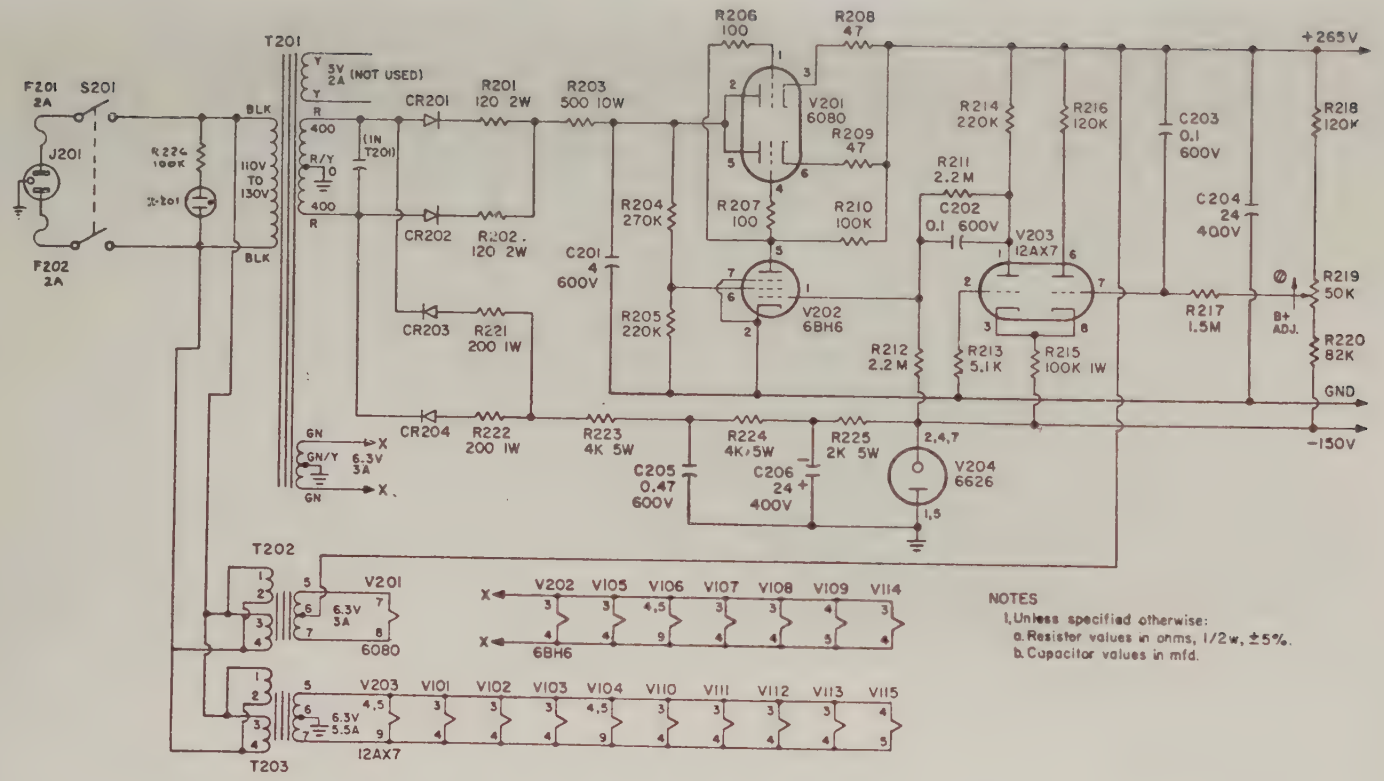
MODEL 412 INSTRUCTION MANUAL

SECTION VI

PARTS LIST

B. Power Supply

Part No.	Description	B/A Desig.
R207	100 Ω, 1/2 W, 5%, comp.	RCE 101J
208	47 Ω, 1/2 W, 5%, comp.	RCE 470J
209	47 Ω, 1/2 W, 5%, comp.	RCE 470J
210	100 K, 1/2 W, 5%, comp.	RCE 104J
211	2.2 M, 1/2 W, 5%, comp.	RCE 225J
212	2.2 M, 1/2 W, 5%, comp.	RCE 225J
213	5.1 K, 1/2 W, 5%, comp.	RCE 512J
214	220 K, 1/2 W, 5%, comp.	RCE 224J
215	100 K, 1 W, 5%, comp.	RCG 104J
216	120 K, 1/2 W, 5%, comp.	RCE 124J
217	1.5 M, 1/2 W, 5%, comp.	RCE 155J
218	120 K, 1/2 W, 5%, comp.	RCE 124J
219	50 K pot., 2 W, 5%, carbon	RV 503-3
220	82 K, 1/2 W, 5%, comp.	RCE 823J
221	200 Ω, 1 W, 5%, comp.	RCG 201J
222	200 Ω, 1 W, 5%, comp.	RCG 201J
223	4 K, 5 W, 5%, wirewound	RW 402-2
224	4 K, 5 W, 5%, wirewound	RW 402-2
225	2 K, 5 W, 5%, wirewound	RW 202-1
S201	Switch DPDT	ST-1
T201	Transformer, Sola 7106	TP-46
202	Transformer, Triad F-63	TF-16
203	Transformer, Triad F-65	TF-15
V201	6080	
202	6BH6	
203	12AX7	
204	6626	

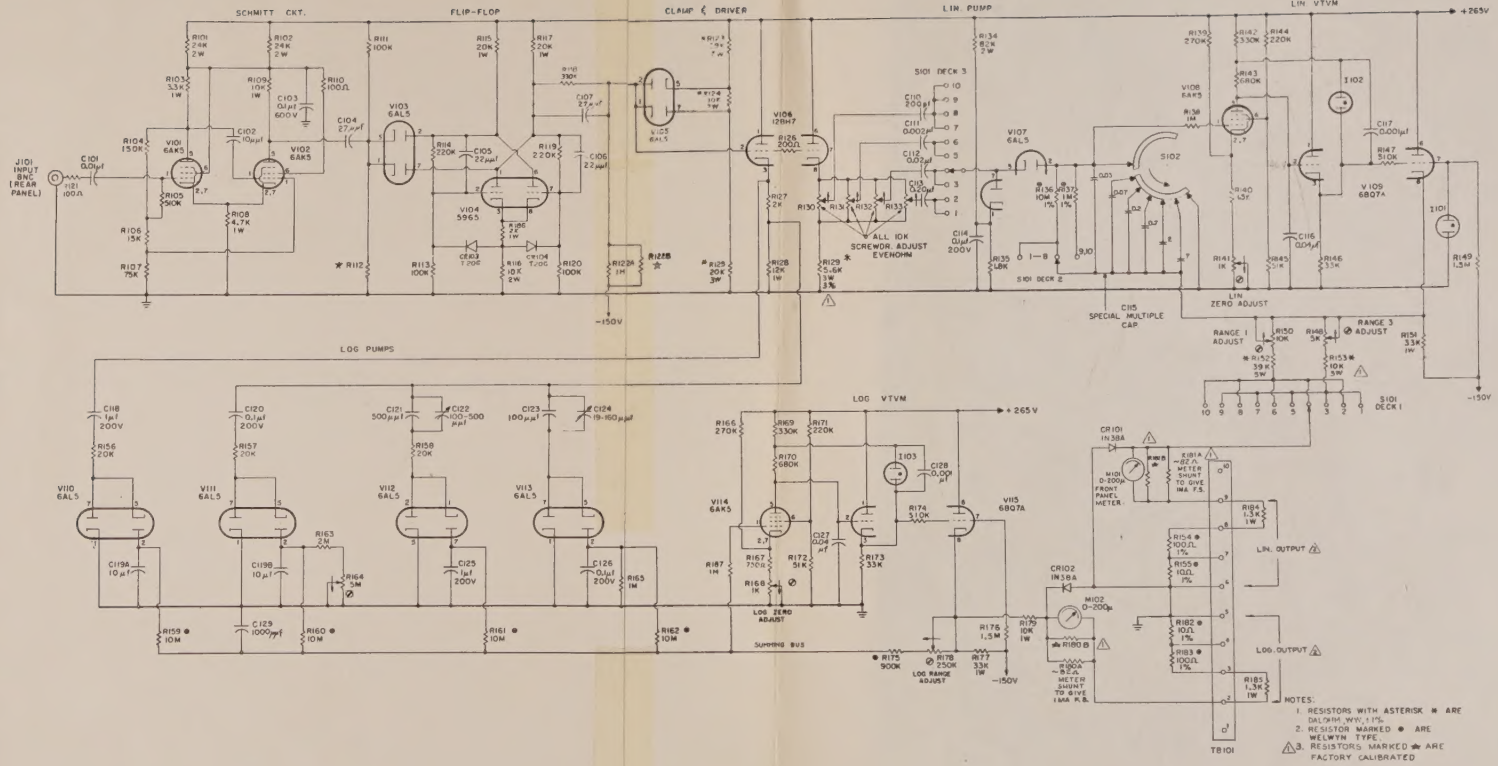


NOTES
1. Unless specified otherwise:
   a. Resistor values in ohms, 1/2w, ±5%.
   b. Capacitor values in mfd.

SCHEMATIC - POWER SUPPLY, RATEMETER
MODEL 412 (PRODUCTION & INSTRUCTION)

C-10021-73 A

3c



DIAGRAM, ELECTRICAL CIRCUIT
PRECISION DUAL RATEMETER
MODEL 412

D-10021-72 A

MISSILE & SPACE SYSTEMS DIVISION
DOUGLAS AIRCRAFT COMPANY, INC.
SANTA MONICA, CALIFORNIA